Clark County NPDES
Lacamas Lake Monitoring

Quality Assurance Project Plan

Version 1.0 November 2004

Project Name:	Lacamas Lake Monitoring
Project Code:	LLMP
Agency Name:	Clark County Washington
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Department:	Public Works Water Resources
Funding Source:	Clark County Clean Water Fee

Approvals:

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Purpose of the Quality Assurance Project Plan

Clark County Public Works Water Resources (Water Resources) follows the general Quality Assurance Project Plan (QAPP) format defined by the State of Washington Department of Ecology (Ecology) (Lombard and Kirchmer, 2001). Water Resources requires a QAPP for each monitoring project. The plan addresses project design, schedule, methods of data collection and management, quality assurance and quality control requirements, data analysis, and reporting.

Background and Problem Statement

Historical Information

Lacamas Lake and Round Lake are located in Clark County, Washington, on the northern boundary of the city of Camas. In a county with few lakes, Lacamas and Round Lakes are recognized as an important recreational resource. Fishermen, swimmers, boaters, and hikers utilize the lakes and their shores year-round.

Periodic water quality monitoring by the Southwest Washington Health District (SWHD) from 1974-1980 first raised concerns about water quality in Lacamas Lake and its tributary streams. In 1983, the Clark County Intergovernmental Resource Center (IRC) received a grant from the Washington Department of Ecology (Ecology) to fund a Phase I Diagnostic and Restoration Analysis (SRI, 1985).

Based on this investigation, Lacamas and Round Lake were categorized as "eutrophic". The terms oligotrophic, mesotrophic, and eutrophic are often used to characterize lakes according to a low, medium, or high level of algae production, respectively. Over time, lakes naturally move slowly along this continuum in a direction toward eutrophic conditions (high algal production). In some cases, however, this movement can be dramatically accelerated due to human activities in a lake or watershed.

It should be noted that trophic categories are not meant to convey value judgments. Oligotrophic conditions do not necessarily imply "good" water quality or a "healthy" lake. Conversely, eutrophic conditions do not always mean a lake is impaired or has "bad" water quality. Rather, trophic categories describe the amount of nutrient enrichment and biological productivity in a lake, whereas terms like "healthy" and "impaired" refer to the condition of a lake relative to its desired uses or natural condition (Snohomish County, 2003).

In the case of Lacamas Lake, accelerated eutrophication has dramatically altered the lake from its natural historical condition and resulted in conditions that may impair current desired uses such as fishing, swimming, and aesthetic enjoyment.

Water quality problems associated with Lacamas Lake eutrophication in 1984 included severe dissolved oxygen depletion, poor water clarity, high levels of algae growth, nuisance blue-green algae blooms, and dense beds of aquatic macrophytes. These conditions are typical of a highly eutrophic lake, and were attributed primarily to excessive inputs of the nutrient phosphorus due to human activities in the Lacamas watershed.

Subsequently, the Lacamas Lake Restoration Program (LLRP), supported in part by grants from the Centennial Clean Water Fund and Section 319 Fund, implemented a program of agricultural Best Management Practice (BMP) installation, water quality monitoring, and public education in the watershed between 1987 and 2001. Those efforts were aimed at reducing the amount of phosphorus in Lacamas Lake and are summarized in the Lacamas Lake Restoration Program Final Report (Hutton, 2002), Lacamas Lake Restoration Program: WY2000 and WY 2001 Water

Quality Monitoring (Schnabel, 2002), and the Lacamas Lake Watershed Restoration Project Program Review (E&S, 1998). These reports and others relating to Lacamas Lake are available from Clark County Water Resources.

The LLRP was successful in reducing the number of agricultural sources of phosphorus to the lake, establishing a greater scientific understanding of its water quality and dynamics, and raising awareness among the citizens of Clark County. However, despite the fact that annual loading and in-lake concentrations of phosphorus declined, the lake continued to exhibit the signs of eutrophication observed in the early 1980s. Shifting land-use patterns have resulted in accelerated encroachment of residential, commercial, and recreational development into the watershed. These changes present a continuing challenge to the protection and maintenance of desired beneficial uses in Lacamas and Round Lakes.

Clark County Clean Water Program

Since the expiration of the Lacamas grant in December 2001, Clark County Water Resources has continued ambient monitoring activities in Lacamas Creek and Lacamas Lake under its NPDES Clean Water Program. The Clean Water Program was initiated in 2000 to increase protection for our streams, lakes, and groundwater. The program began in response to the increasing need for stewardship of local resources, as well as federal and state mandates for local government agencies to better control and clean stormwater runoff. The Clean Water Fee, which is paid by property owners in unincorporated Clark County, supports the enhanced levels of service required to accomplish Clean Water Program goals.

The Clean Water Program is committed to building and implementing a comprehensive monitoring program that supports efforts to:

- Identify water quality problems and their sources
- Document existing health of our lakes and streams and track long-term changes
- Plan appropriate projects to improve water quality
- Demonstrate compliance with the county's National Pollutant Discharge Elimination System (NPDES) permit for the stormwater system

The Lacamas Lake monitoring project helps fulfill the requirement for receiving-water characterization identified under the County's NPDES stormwater permit. In the absence of a coordinated lake management and monitoring approach by other local and state jurisdictions, Water Resources continues ambient monitoring of this resource to enhance future lake management decisions and improve the evaluation of potential changes in lake health.

QAPP revision

This document replaces the previous QAPP which was approved by Ecology in 1998. The objectives of the 1998 QAPP were addressed through lake and stream monitoring activities between 1998 and 2003. Changes to the scope, objectives, and procedures in the post-grant period necessitate an update to the QAPP to reflect current and future monitoring activities.

Organization and Timeline

Project Staff
Lacamas Lake monitoring activities are administered through Clark County Public Works Water Resources as part of the county's NPDES Clean Water Program.

Client:	Earl Rowell, Water Resources manager
Supervisor:	Rod Swanson, Senior Planner
Project Manager:	Jeff Schnabel, Water Resource Scientist
QC Coordinator:	Ron Wierenga, Water Resource Scientist
Project Team:	Bob Hutton, Planner III
	Water Resource Technician
	Jeff Schnabel

Laboratory Contracts
Laboratory water quality analyses for the project are performed by North Creek Analytical Laboratories (NCA), an Ecology-accredited facility located in Beaverton, Oregon. Phytoplankton and chlorophyll-*a* analyses are performed by Aquatic Analysts, a qualified laboratory located in White Salmon, Washington. Contact information is located below.

Howard Holmes
North Creek Analytical
9405 SW Nimbus Avenue
Beaverton, OR 97008-7132
503-906-9200

Jim Sweet
Aquatic Analysts
22 Acme Road
White Salmon, WA 98672
509-493-8222

Laboratory contracts may change as project needs evolve.

Budget
Budget estimates for the LLMP are found in Table 1:

Table 1: LLMP annual budget estimate

Budget Category	Estimated Cost (annual)
Field staff	$4000.00
Vehicle	$200.00
Laboratory	$2500.00
Sample shipping	$200.00
Equipment maintenance	$500.00
Data management	$1500.00
Reporting	$1500.00
Contingency	$3000.00
Total	**$13,400.00**

Project Timeline
The LLMP is an ongoing ambient monitoring project. It is intended to provide data over an extended time period. The project is designed to collect data at a temporal scale appropriate for long-term trend analysis as well as short-term assessment of lake condition. This QAPP and future revisions or addendums apply to all monitoring under the LLMP beginning in May 2004.

Project Description

Goals and Decision Statement

LLMP data are used to assess current lake health and define long-term trends in lake conditions. Criteria for these determinations include 1) comparison of physicochemical data to water quality standards and aquatic life criteria; 2) calculation of trophic state indices; 3) calculation of statistical trends based on the long-term dataset; and 4) comparison of lake characteristics to historical data and regional expectations.

Objectives

The primary objectives of the Lacamas Lake Monitoring Project are to:

- Assess overall lake health in terms of beneficial use support and water quality criteria
- Identify and describe trends in lake trophic status using nutrient and algal indicators
- Disseminate accurate information to local and state agencies, the general public, and other stakeholders

Sampling Design

Stations

Figure 1 shows the location of the lake station utilized for routine LLMP ambient monitoring. Station LACL11 is located over the deepest part of Lacamas Lake, and corresponds to the location of ambient water quality monitoring in most previous Lacamas Lake studies.

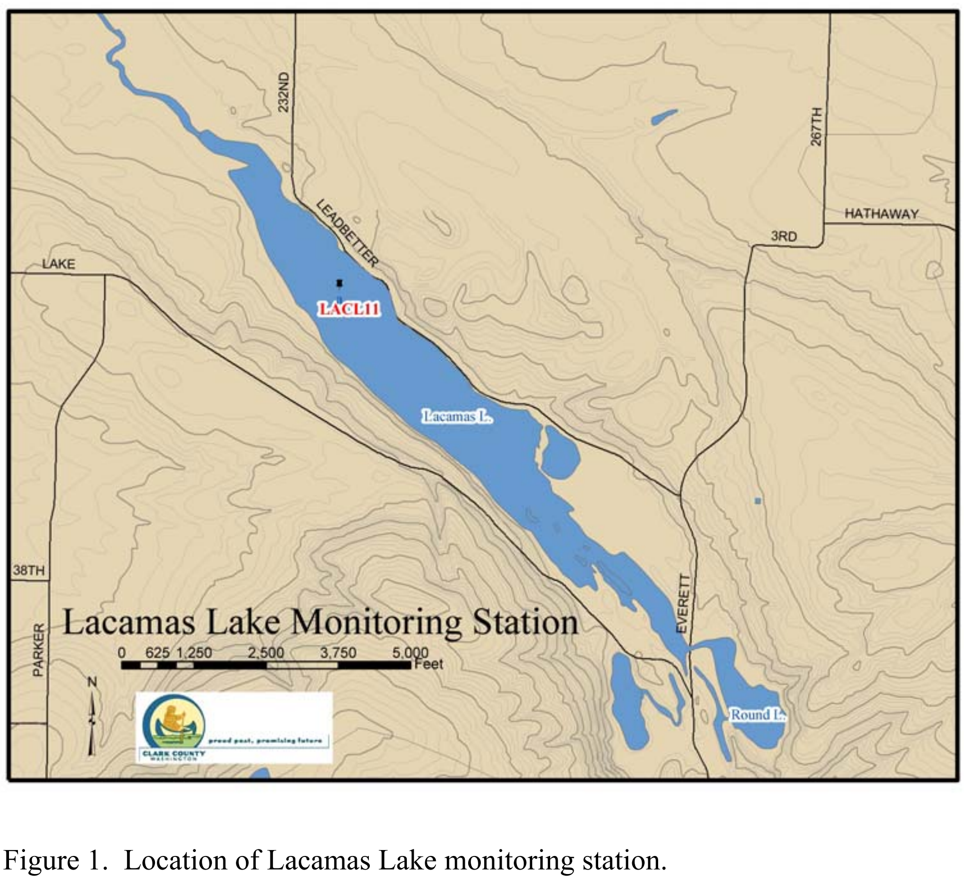

Figure 1. Location of Lacamas Lake monitoring station.

Sampling schedule
Samples, measurements, and observations are collected at station LACL11 on a monthly basis from May through October (summer season). Tentative monthly sampling dates are randomly selected, but may be revised due to equipment issues, staff availability, or inclement weather.

Sample frequencies and collection methods are addressed in the Field Procedures section.

Representativeness
LLMP data are intended to be representative of lake conditions at the time of sample collection. Water Resources utilizes standard monitoring procedures designed to facilitate the collection of representative samples. Sampling on randomly-selected dates, sampling at a consistent location, and utilizing standard procedures all facilitate the collection of representative samples and measurements.

In most cases sampling is performed at approximately the same time during each trip to minimize diurnal effects on characteristics which show large diurnal variations (temperature, pH, dissolved oxygen, chlorophyll-*a*, water clarity).

Data comparability
LLMP data are compared to data collected during previous Lacamas Lake studies and combined with the existing long-term dataset for trend analyses. Data are also intended to be comparable to other local and regional lake studies. Long-term comparability of LLMP data with other data is facilitated by utilizing and documenting standard procedures for data collection and analyses.

Any long-term monitoring program is likely to experience changes in sampling or analytical procedures that can potentially affect results. Normally, changes will result in improved precision or reduced bias, but even improvements in procedures can cause difficulty in the analysis of long-term trends (Hallock, 2003). Issues of this type are likely to occur in the LLMP and will be addressed as part of ongoing data analysis.

Quality Objectives

Field and Lab
Analytical methods, detection or precision limits, and Measurement Quality Objectives (MQOs) for accuracy, precision, and bias are listed in Table 2. MQOs for the LLMP are set at generally accepted targets for ambient water quality monitoring projects. Data quality objectives and quality control procedures for laboratory characteristics are detailed in NCAs quality assurance documents (November, 2001).

Collection, preservation, transportation, and storage of samples follow standard procedures designed to reduce most sources of sampling bias. Analytical bias is minimized by adherence to the methods listed in Table 2. The laboratory employs quality control procedures appropriate to the analytical procedures, including analysis of method blanks, matrix spikes, and check standards.

Table 2. Analytical methods and measurement quality objectives

Characteristic	Method	Reference	Reporting Limit	Precision	Accuracy	Bias
		lab	conc/units	%RSD	units/% error	%REC
temperature	thermistor	na	0.01 C	na	±0.15 C	na
dissolved oxygen	membrane electrode	na	0.01 mg/L	na	±0.2 mg/L	±20% (winkler)
conductivity	electrode	na	4 digits	na	±0.5% of reading	na
pH	glass electrode	na	0.01 units	na	±0.2 units	na
turbidity	nepholometric	SM 2130B	0.01 NTU	na	±2% of reading	na
total phosphorus	colorimetric	EPA 365.1	0.02 mg/L	10%	25%	5%
total kjeldahl nitrogen	colorimetric	EPA 351.2	0.5 mg/L	10%	25%	5%
nitrate+nitrite nitrogen	colorimetric	EPA 353.2	0.05 mg/L	10%	25%	5%
chlorophyll *a*	fluorometric	SM 10200H	0.2 ug/L	20%	45%	5%
phytoplankton	slide transect	na	na	na	na	na

Field Procedures

Equipment calibration, quality assurance, and field data collection protocols for data collected by the LLMP are described below and in Standard Procedures for Monitoring Activities: Clark County Water Resources Section (June 2002). All field activities are conducted by 2-person field crews. Sample containers for laboratory delivery are labeled in indelible ink with the following information:

- Clark County
- Lacamas
- Station Name
- Date
- Time

Water quality samples are collected in properly preserved bottles prepared by the laboratory, and stored on ice or refrigerated until delivery to NCA. Water samples are picked up by laboratory personnel within 24 hours of collection. Formal chain of custody documentation is maintained for all samples sent to NCA.

Logs are kept of all field activities. Logs consist of standardized field sheets recording field measurements, ancillary data, and staff observations. Logs are waterproof and entries made with pencil or indelible ink. Corrections are made by drawing a single line through the error such that it remains legible, writing the correction adjacent to the error, and initialing the correction. Records are cross-checked for consistency between labels, custody documents, field logs, and other relevant data. Logs are archived in Water Resources files.

Lake samples are collected at station LACL11. Table 3 contains characteristics, sampling schedule, collection type, and container requirements for the LLMP.

Field measurements for water temperature, dissolved oxygen, ph, and conductivity are collected at 1m intervals using a calibrated Hydrolab Datasonde 4 multi-probe and Surveyor 4 data-logger.

Water samples for total phosphorus, total Kjeldahl nitrogen, and nitrate + nitrite nitrogen analyses are collected from the epilimnion and hypolimnion using a vertical VanDorn-style sampling bottle. Secchi disk readings are taken on the shady side of the boat, with eye level just above the gunwale.

Chlorophyll *a* and phytoplankton samples are obtained by compositing three grab samples equally spaced through the photic zone. Photic zone depth is estimated as 2 times the measured secchi depth. Composite grabs are collected using a VanDorn-style sampling bottle and composited in a nalgene carboy, from which sub-samples are drawn. Chlorophyll-*a* samples are collected in bottles preserved with $MgCO_3$ and kept on ice until shipment to Aquatic Analysts. Phytoplankton samples are collected in bottles preserved with Lugol's solution and kept on ice until shipment to Aquatic Analysts.

Table 3. Sampling schedule, collection methods, and container requirements.

Parameter	Schedule*	Collection	Container/ Preservation
secchi depth	monthly	visual measurement	na
temperature	monthly	field meter, vertical profile	na
dissolved oxygen	monthly	field meter, vertical profile	na
conductivity	monthly	field meter, vertical profile	na
pH	monthly	field meter, vertical profile	na
turbidity	monthly	field meter, 2 depths	na
total phosphorus	monthly	manual grab, 2 depths	250ml LPDE/sulfuric acid
total kjeldahl nitrogen	monthly	manual grab, 2 depths	250ml LPDE
nitrate + nitrite nitrogen	monthly	manual grab, 2 depths	250ml LPDE/sulfuric acid
chlorophyll *a*	monthly	Composite, photic zone	125 mL brown LPDE/$MgCO_3$
phytoplankton	monthly	Composite, photic zone	250ml brown LPDE/Lugol's
*May - Oct only			

Laboratory Procedures

Ammonia, nitrate + nitrite, total Kjeldahl nitrogen, total phosphorus, orthophosphorus, total suspended solids, and chlorophyll *a* analyses are conducted by NCA. All procedures are performed according to NCA's Ecology-approved quality assurance program and according to accepted conventions for data manipulation and reporting as described in Standard Methods (APHA, 1992). Table 2 shows constituents measured, analytical methods, and reporting limits. Phytoplankton analysis is performed by Aquatic Analysts according to the procedures described in Algal Analytical Procedures (Aquatic Analysts, 2001).

Quality Control

Laboratory QC

Laboratory check standards, matrix spikes, analytical duplicates, and blanks are analyzed in accordance with the NCA Quality Assurance Program. QC results are reported to Water Resources along with sample data. Laboratory data reduction, review, assessment, and reporting are performed according to the NCA Quality Assurance Program.

Field QC
Field QC sample types, frequencies, and definitions for LLMP monthly water quality samples are found in Table 4.

Duplicate lake samples and field meter measurements are collected every other month. Transfer blanks and transport blanks are collected annually.

Field meters are calibrated and maintained in accordance with manufacturer's instructions. Conductivity check standards and a National Institute of Standards and Technology (NIST) certified thermometer are used to verify field meter accuracy. Calibration logs are completed during each calibration and are archived in Water Resources files. Calibration drift in pH meters is checked against pH buffer solutions, and dissolved oxygen measurements are verified using a modified Winkler titration. These activities are used to confirm that field instruments are attaining stated accuracy and resolution specifications.

Table 4. SCMP QC sample types, frequencies, and definitions.

Field QC sample type	Frequency	Definition
Field measurement replicate	every other month	repeat field meter measurements at one depth from vertical profile
Water sample duplicate	every other month	duplicate sample collected for laboratory analysis
Transfer blank	annually	D.I. water sample collected in field with sampling equipment
Transport blank	annually	D.I. water sample prepared in office and carried through field trip

Corrective Actions
Data quality problems encountered in the analysis of QC samples are addressed as needed through re-calibration, modifications to the field procedures, increased staff training, or by qualifying results appropriately. Documentation of corrective action steps includes problem identification, investigation procedures, corrective action taken, and effectiveness of the corrective action.

Data Management Procedures
Data management procedures for the LLMP will be revised as Water Resources develops a centralized monitoring database. In the interim, data management procedures are as follows:

Data are stored in Excel spreadsheets at Water Resources, along with digital copies of laboratory reports. Hard copies of laboratory reports are stored in a project binder. Laboratory data packets are also archived annually on the county's Digital Imaging System. QC data, including field measurement replicates, sample duplicates, transfer and transport blanks, paired samples, and field checks for pH and dissolved oxygen, are stored in Excel spreadsheets at Water Resources. The QC coordinator and project manager are responsible for validating and cross-checking data entry.

Laboratory data are reported by NCA in digital format. The laboratory data package includes QC results and an explanation of any necessary data qualifiers. Laboratory data and field measurements are entered into spreadsheets manually. Manually entered data are cross-checked by the project manager and/or QC coordinator for entry errors.

Data Analysis

Standard data analysis procedures utilize Microsoft Excel, Minitab, and WQStat Plus software packages. Statistical trends are evaluated using the non-parametric seasonal Kendall test. Typical graphical displays include time-series and box-and-whisker plots, as well as bar charts.

Data analyses include the following:

- Determination of monotonic summertime trends in monthly TP and TKN for the epilimnion and hypolimnion.
- Determination of monotonic summertime trends in monthly water clarity (secchi disk).
- Calculation of annual summertime total phosphorus, secchi disk, chlorophyll-*a*, and phytoplankton Trophic State Index (TSI) values.
- Determination of monotonic summertime trends in monthly TSI values.
- Comparison of current TP, TKN, secchi, and turbidity measurements with state criteria and/or regional expectations.
- Assessment of summertime habitat availability, based on vertical profiles of water temperature and dissolved oxygen.
- Summary graphics of recent phytoplankton community structure.

Additional analyses may be performed as necessary.

Audits and Reports

Audits

The project manager and QC coordinator periodically review the field data, methods, lab results, and data management activities to make an assessment of the project and identify corrective actions or method revisions.

Reports

Reporting for the Lacamas Lake project follows a five-year cycle. A data summary report is produced after year three monitoring, and a technical report is produced after year five. Between scheduled reporting periods, data are managed electronically and made available to users on request. Additional reports may be produced at the request of management. Project activities are also summarized in the annual NPDES municipal stormwater permit report to Ecology.

Data report and technical report contents are defined in Water Resources Report Preparation and Distribution Practices (December 2003). In general, data reports include only data and brief summary graphics, while technical reports include more rigorous data analysis and interpretation.

Reports generally do not provide a comprehensive discussion of historical lake monitoring results. Rather, their intent is to update and build upon the information provided by previous studies. Data from each reporting period are appended to the historical database to allow trend analyses using the most complete long-term data set. Overall lake condition, trophic status, and trends are discussed in the context of beneficial use support. Management implications and recommendations for future monitoring are also presented.

Reports address project methods, summarize data accuracy and completeness, and describe significant data quality issues. All reports are peer reviewed by Water Resources staff.

LLMP reports are provided to relevant local and state agencies, and may be included as attachments to the county's annual NPDES permit compliance report to Ecology. Reports are posted on the Water Resources web page to facilitate dissemination of information to the public.

Data Review, Verification, and Validation

During each sample trip, field crews review field and sample logs to confirm that all necessary field measurements and samples have been collected. Laboratory QC results are reviewed and verified by NCA staff and documented in data reports to Water Resources. Upon receipt, laboratory data are reviewed for errors, omissions, and data qualifiers prior to data entry.

Data verification involves examination of QC results analyzed during the project to provide an indication of whether the precision and bias MQOs have been met. To evaluate whether precision targets have been met, pairs of duplicate sample results are pooled and an estimate of standard deviation is calculated. This estimate, divided by the mean concentration of the duplicate results and converted to percent, is used to judge whether the %RSD target has been met.

To evaluate whether bias targets have been met, the mean percent recovery of the check standards should be within +/- %bias target of the true value (e.g. true value +/- 10%). Unusually high blank results indicate bias due to contamination that may affect low-level results. To evaluate whether the target for reporting limit has been met, results will be examined to determine if any of the values exceed the required reporting limits.

Data validation consists of a detailed examination of the complete data package using professional judgment to assess whether the procedures in the SP's and QAPP have been followed. Data validation is performed by the project manager and QC coordinator.

Data review and verification are summarized semi-annually, while data validation is performed annually.

Data Quality Assessment

Taking into account the results of data review, verification, and validation, an assessment will be made annually as to whether the data are of sufficient quality to attain project objectives.

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